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GATE SOLVED PAPER - EE

2014-2

General Aptitude

Q. 1 - Q. 5 Carry one mark each.

Q. 1 Choose the most appropriate phrase from the options given below to complete the following sentence.
India is a post-colonial country because

(A) it was a former British colony

(B) Indian Information Technology professionals have colonized the world

(C) India does not follow any colonial practices

(D) India has helped other countries gain freedom

Sol. 1 Correct option is (A).
A pronoun (it) is used after a conjunction (because), so the complete sentence is: India is a post-colonial country because it was a former British colony.

Q. 2 Who _ _ _ _ _ _ was coming to see us this evening ?

(A) you said (B) did you say

(C) did you say that (D) had you said

Sol. 2 Correct option is (B).
Who did you say was coming to see us this evening ?
This is a question and 'who' in that sentence is an interrogative pronoun. For that reason we need to invert subject and verb and write 'did you say ?'

Q. 3 Match the columns

Column 1		Column 2	
1.	eradicate	P.	misrepresent
2.	distort	Q.	soak completely
3.	saturate	R.	use
4.	utilize	S.	destroy utterly

(A) 1 : S, 2 : P, 3 : Q, 4 : R (B) 1 : P, 2 : Q, 3 : R, 4 : S

(C) 1 : Q, 2 : R, 3 : S, 4 : P (D) 1 : S, 2 : P, 3 : R, 4 : Q

Sol. 3 Correct option is (A).
Eradicate- to remove or destroy utterly
Distort- to give a false, perverted, or disproportionate meaning to; misrepresent
Saturate-to soak, impregnate, or imbue thoroughly or completely
Utilize-to put to use

Q. 4 What is the average of all multiplies of 10 from 2 to 198 ?

(A) 90 (B) 100

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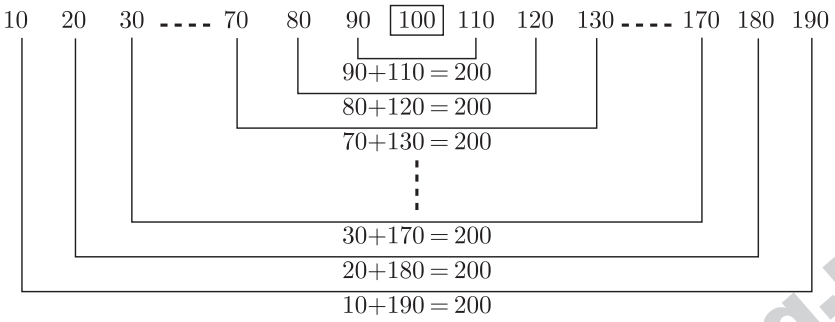
(C) 110 (D) 120

Sol. 4 Correct option is (B).



$$\text{Average value} = \frac{200 \times 9 + 100}{19}$$
$$= 100$$

Q. 5 The value of $\sqrt{12+\sqrt{12+\sqrt{12+...}}}$ is

(A) 3.464 (B) 3.932

(C) 4.000 (D) 4.444

Sol. 5 Correct option is (C).

Given expression can be written as

$$x = \sqrt{12+\sqrt{12+\sqrt{12+...}}}$$
$$x = \sqrt{12+x} \qquad \because x = \sqrt{12+\sqrt{12+...}}$$
$$x^2 = 12+x$$
$$x^2 - x - 12 = 0$$
$$x^2 - 4x + 3x - 12 = 0$$
$$x(x-4) + 3(x-4) = 0$$
$$(x+3)(x-4) = 0$$
$$x = -3, 4$$
$$x = 4 \qquad (x \text{ can not be negative})$$

Q. 6 - Q. 10 Carry two marks each.

Q. 6 The old city of Koenigsberg, which had a German majority population before World War 2, is now called Kaliningrad. After the events of the war, Kaliningrad is now a Russian territory and has a predominantly Russian population. It is bordered by the Baltic Sea on the north and the countries of Poland to the south and west and Lithuania to the east respectively. Which of the statement below can be inferred from this passage ?

(A) Kaliningrad was historically Russian in its ethnic make up

(B) Kaliningrad is a part of Russia despite it not being contiguous with the rest of Russia

(C) Koenigsberg was renamed Kaliningrad, as that was its original Russain name

(D) Poland and Lithuania are on the route from Kaliningrad to the rest of Russia

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Sol. 6 Correct option is (A).
Ethnic cleansing or makeup is the process of using violent methods to force certain groups of people out of a particular area or country. We can infer that Kaliningrad was historically Russian in its ethnic make up.

Q. 7 The number of people diagnosed with dengue fever (contracted from the bite of a mosquito) in north India is twice the number diagnosed last year. Municipal authorities have concluded that measures to control the mosquito population have failed in this region.
Which one of the following statements, if true, does not contradict this conclusion ?

(A) A high proportion of the affected population has returned from neighbouring countries where dengue is prevalent

(B) More cases of dengue are now reported because of an increase in the Municipal Office's administrative efficiency

(C) Many more cases of dengue are being diagnosed this year since the introduction of a new and effective diagnostic test

(D) The number of people with malarial fever (also contracted from mosquito bites) has increased this year

Sol. 7 Correct option is (D).
The number of people with malarial fever (also contracted from mosquito bites) has increased this year.

Q. 8 If x is real and $|x^2-2x+3|=11$, then possible values of $|-x^3+x^2-x|$ include

(A) 2, 4 (B) 2, 14

(C) 4, 52 (D) 14, 52

Sol. 8 Correct option is (D).

$$|x^2-2x+3|=11$$

So we can have two possible equalities

$$x^2-2x+3=11 \text{ or } x^2-2x-8=0 \quad ...(i)$$

and $$x^2-2x+3=-11 \text{ or } x^2-2x+14=0 \quad ...(ii)$$

For eq (ii),

Discriminant $\Delta = b^2-4ac$

$$=4-4(1)(14)<0$$

So, roots of equation (ii) will be imaginary, but given x is real. Therefore we dont consider this equation.

For eq(i)

Discriminant $\Delta = b^2-4ac$

$$=4-4(1)(-8)<0$$

So, roots of equation (i) will be real.

$$x^2-2x-8=0$$
$$x^2-4x+2x-8=0$$
$$(x-4)(x+2)=0$$
$$x=-2, 4$$

For $x=-2$

$$|-x^3+x^2-x|=|-(-8)+(4)-(-2)|=|8+4+2|=14$$

For $x=4$

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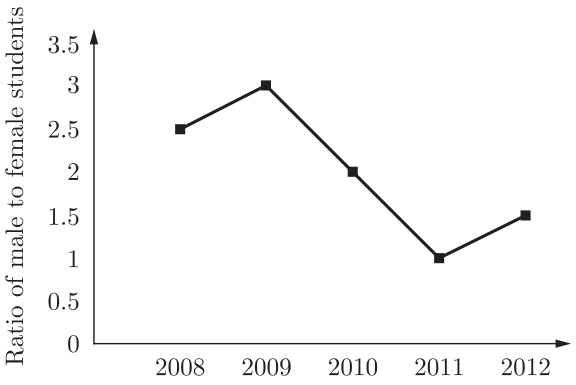
$$\left|-x^3+x^2-x\right|\left|-(64)+(16)-4\right|=52$$

Q. 9 The ratio of male to female students in a college for five years is plotted in the following line graph. If the number of female students doubled in 2009, by what percent did the number of male students increase in 2009 ?



Sol. 9 Correct answer is 140.

Let male students in 2006 be x_1 and female students be y_1. From the given graph we can see that in 2008 ratio of male to female students is 2.5. So

$$\frac{x_1}{y_1}=2.5$$

$$x_1=2.5y_1$$

Let number of male student in 2009 be x_2 and number of female students be y_2 . From the graph we can see that in 2009, ratio of male to female students is 3. So

$$\frac{x_2}{y_2}=3$$

Given that number of female students is double in 2009, so we have $y_2=2y_1$. The above ratio now becomes as

$$\frac{x_2}{2y_1}=3$$

$$x_2=6y_1$$

% of No. of male students increased in 2009

$$\Delta x=\frac{x_2-x_1}{x_1}\times 100$$

$$\Delta x=\frac{6y_1-2.5y_1}{2.5y_1}\times 100=140$$

Q. 10 At what time between 6 a.m. and 7 a.m. will the minute hand and hour hand of a clock make an angle closest to 60° ?

(A) 6 : 22 a.m. (B) 6 : 27 a.m.

(C) 6 : 38 a.m. (D) 6 : 45 a.m.

Sol. 10 Correct option is (A).

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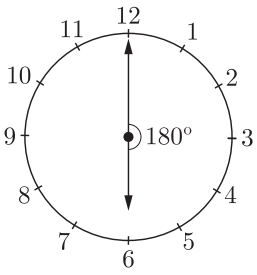
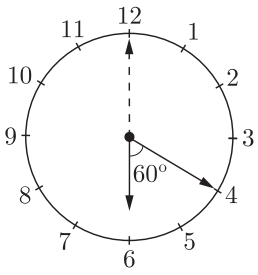


6:00 a.m.



After x minutes

As shown in Figure above, at 6:00 a.m. initial angle between minute and hour hand is 180°. As we know that hour hand completes 30° in every hour (60 minutes), so angle moved by hour hand in 1 minute is $\frac{30}{60}$. Similarly, minute hand complete 360° in every hour, so angle moved by minute hand in 1 minute is $\frac{360}{60}$. Let us assume that after x minutes the angle is 60°. Let us assume that after x minutes the angle is 60°.

$$60^\circ = 180^\circ + \underbrace{\left(\frac{360^\circ}{60^\circ}\right)x}_{\substack{\text{angle moved}\\ \text{by hour hand}}} - \underbrace{\left(\frac{30^\circ}{60^\circ}\right)x}_{\substack{\text{angle moved}\\ \text{by min hand}}}$$

$$60^\circ = 180^\circ + 6x - 0.5x$$

$$5.5x = 120$$

$$x = \frac{120^\circ}{6.5} = 21.8 \text{ min}$$

Therefore approximately at 6.22 am the angle will close to 60° between the hour hand and minute hand.

END OF THE QUESTION PAPER

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Electrical Engineering

Q. 1 - Q. 25 Carry one mark each.

Q. 1 Which one of the following statements is true for all real symmetric matrices ?
(A) All the eigenvalues are real
(B) All the eigenvalues are positive
(C) All the eigenvalues are distinct
(D) Sum of all the eigenvalues is zero

Sol. 1 Correct option is (A).
Corollary: Every real symmetric matrix has eigenvalues which are all real numbers.

Q. 2 Consider a dice with the property that the probability of a face with n dots showing up proportional to n. The probability of the face with three dots showing up is_ _ _ _.

Sol. 2 Correct answer is 0.14 .
On the first dot probability $\propto 1$
On the second dot probability $\propto 2$

.
.
.

On the sixth dot probability $\propto 6$

$$\text{Total probability} = 1+2+3+4+5+6$$
$$= 21$$
$$\text{Probability of } 3^{\text{rd}} \text{ dot} = \frac{3}{21} = \frac{1}{7} = 0.14$$

Q. 3 Minimum of the real valued function $f(x) = (x-1)^{2/3}$ occurs at x equal to
(A) $-\infty$ (B) 0
(C) 1 (D) ∞

Sol. 3 Correct option is (C).

$$f(x) = 10(x-1)^{2/3}$$

Since $f(x)$ is a real valued function $(x-1)$ can not be negative, because in that case fractional power of negative number is imaginary. So at $x = 1$, the value of $f(x)$ will be minimum.

Q. 4 All the values of the multi-valued complex function 1^i, where $i = \sqrt{-1}$, are
(A) purely imaginary (B) real and non-negative
(C) on the unit circle (D) equal in real and imaginary parts

Sol. 4 Correct option is (B).
We can write

$$1 = \cos(2n\pi) + i\sin(2n\pi), \text{ where } n \text{ is an integer}$$

or, $1 = e^{i(2n\pi)}$

So, $1^i = \left[e^{i(2n\pi)}\right]^i$

or $1^i = e^{i^2(2n\pi)}$

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$$1^i = e^{-2n\pi}$$

Therefore all values of 1^i are non-negative and real number.

Q. 5 Consider the differential equation $x^2\frac{d^2y}{dx^2} + x\frac{dy}{dx} - y = 0$. Which of the following is a solution to this differential equation for $x > 0$?

(A) e^x (B) x^2

(C) $1/x$ (D) $\ln x$

Sol. 5 Correct option is (C).

This is a Cauchy-Euler equation, so we substitute $x = e^t$. Then assuming $x > 0$, we have

$$t = \ln x$$

$$\frac{dy}{dx} = \frac{dy}{dt}\frac{dt}{dx}$$

or $$\frac{dy}{dx} = \frac{dy}{dt}\left(\frac{1}{x}\right) \qquad \left[t = \ln x \Rightarrow \frac{dt}{dx} = \frac{1}{x}\right]$$

or $$x\frac{dy}{dx} = \frac{dy}{dt} \qquad \text{...(i)}$$

Now, $$\frac{d^2y}{dx^2} = \frac{1}{x}\left(\frac{d^2y}{dt^2}\frac{dt}{dx}\right) - \frac{1}{x^2}\frac{dy}{dt}$$

$$\frac{d^2y}{dx^2} = \frac{1}{x^2}\left(\frac{d^2y}{dt^2} - \frac{dy}{dt}\right)$$

or $$x^2\frac{d^2y}{dx^2} = \frac{d^2y}{dt^2} - \frac{dy}{dt} \qquad \text{...(ii)}$$

Substituting eq (i) and (ii) in given differential equation, we get

$$\frac{d^2y}{dt^2} - \frac{dy}{dt} + \frac{dy}{dt} - y = 0$$

$$\frac{d^2y}{dt^2} - y = 0$$

Characteristic equation

$$m^2 - 1 = 0$$

$$m = \pm 1$$

Roots are distinct real, so two possible solution

$$y = e^t \text{ and } y = e^{-t}$$

Since $$x = e^t$$

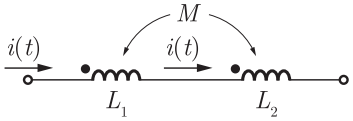
So $$y = x \text{ or } \frac{1}{x} \text{ are two possible solutions.}$$

Q. 6 Two identical coupled inductors are connected in series. The measured inductances for the two possible series connections are $380\,\mu H$ and $240\,\mu H$. Their mutual inductance in μH is _ _ _ _ _.

Sol. 6 Correct answer is 35.

There are two possible connections

(i) Series adding connection



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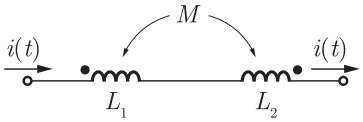
Equivalent inductance

$$L_{eq} = L_1 + L_2 + 2M$$
$$380 = L + L + 2M$$
or $$L + M = 190 \quad ...(i)$$

(ii) Series opposing connection



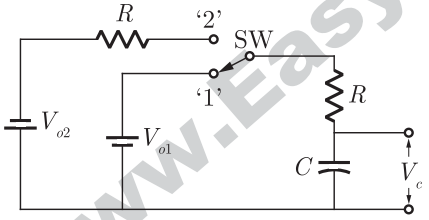
Equivalent inductance

$$L_{eq} = L_1 + L_2 - 2M$$
$$240 = L + L - 2M$$
or $$L - M = 120 \quad ...(ii)$$

Substituting eq (ii) from eq (i), we get

$$2L = 70$$
or $$L = 35 \text{ mH}$$

Q. 7 The switch SW shown in the circuit is kept at position '1' for a long duration. At $t = 0^+$, the switch is moved to position '2'. Assuming $|V_{o2}| > |V_{o1}|$, the voltage $v_c(t)$ across the capacitor is



(A) $v_c(t) = -V_{o2}(1 - e^{-t/2RC}) - V_{o1}$

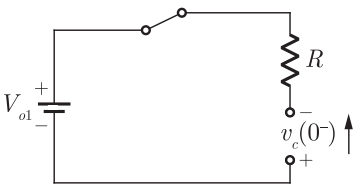
(B) $v_c(t) = V_{o2}(1 - e^{-t/2RC}) + V_{o1}$

(C) $v_c(t) = -(V_{o2} + V_{o1})(1 - e^{-t/2RC}) - V_{o1}$

(D) $v_c(t) = (V_{o2} - V_{o1})(1 - e^{-t/2RC}) + V_{o1}$

Sol. 7 Correct option is (D).

For $t < 0$, the switch was at position '1' and circuit is in steady state. In steady state capacitor behaves as open circuit. So



Therefore $$v_C(0^-) = -V_{o1}$$

Step 2 : For $t > 0$, the switch moves to position 2. Again in steady state capacitor acts as an open circuit.

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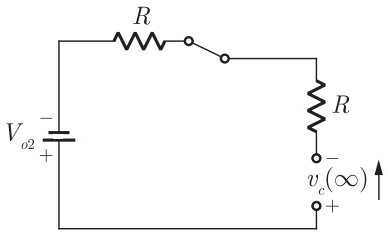


$$v_C(\infty) = V_{o2}$$

Time constant $\tau = R_{Th}C$

R_{Th} is the Thevenin resistance across the capacitor terminal after $t = 0$. So

$$\tau = 2RC$$

Now, at any time $t > 0$, capacitor voltage is given by

$$v_C(t) = v_C(\infty) + [v_C(0) - v_C(\infty)]e^{-t/\tau}$$

$$= V_{o2} + [-V_{o1} - V_{o2}]e^{-t/2RC}$$

or, $$= V_{o2} + [-V_{o1} - V_{o2}]e^{-t/2RC}$$

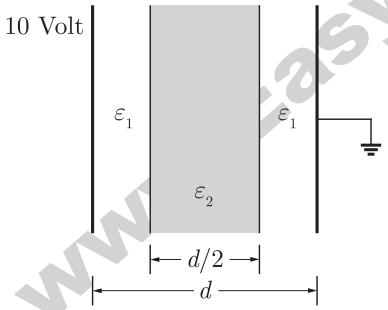
or, $$v_C(t) = V_{o2}(1 - e^{-\frac{t}{2RC}}) - V_{o1}e^{-\frac{t}{2RC}}$$

$$v_C(t)$$

$$= V_{o2}(1 - e^{-\frac{t}{2RC}}) - V_{o1}e^{-\frac{t}{2RC}} - V_{o1}(1 - e^{-\frac{t}{2RC}}) + V_{o1}(1 - e^{-t/2RC})$$

or, $$v_C(t) = (V_{o2} - V_{o1})(1 - e^{-\frac{t}{2RC}}) + V_{o1}$$

Q. 8 A parallel plate capacitor consisting two dielectric materials is shown in the figure. The middle dielectric slab is placed symmetrically with respect to the plates.

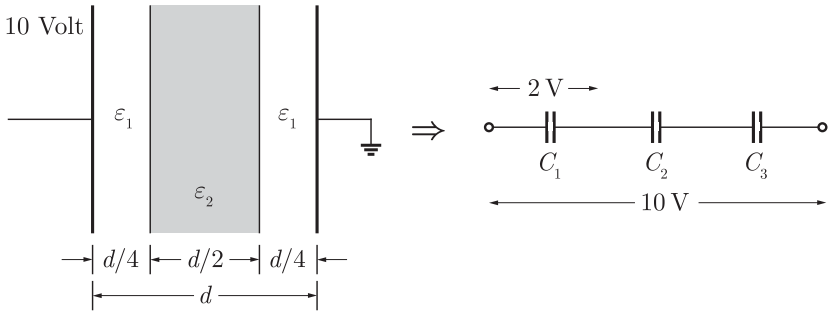


If the potential difference between one of the plates and the nearest surface of dielectric interface is 2 Volts, then the ratio $\varepsilon_1 : \varepsilon_2$ is

(A) 1 : 4 (B) 2 : 3

(C) 3 : 2 (D) 4 : 1

Sol. 8 Correct option is (C).



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As shown in Figure above this arrangement is equivalent to series combination of three capacitors C_1, C_2 and C_3. We have

$$C_1 = \frac{A\varepsilon_1}{d/4} = \frac{4A\varepsilon_1}{d}$$

$$C_2 = \frac{A\varepsilon_2}{d/2} = \frac{2A\varepsilon_2}{d}$$

$$C_3 = \frac{A\varepsilon_1}{d/4} = \frac{4A\varepsilon_1}{d}$$

Now given that voltage across first capacitor is C_1 is 2 V, so we write

$$V_{C1} = \frac{1/j\omega C_1}{\frac{1}{j\omega C_1} + \frac{1}{j\omega C_2} + \frac{1}{j\omega C_3}} \times V_s = 2$$

$$\frac{C_2C_3}{C_2C_3 + C_1C_3 + C_1C_2} \times 10 = 2 \qquad (V_s = 10\text{ V})$$

Substituting values of C_1, C_2 and C_3, we get

$$\frac{8\varepsilon_1\varepsilon_2}{8\varepsilon_1\varepsilon_2 + 16\varepsilon_1^2 + 8\varepsilon_1\varepsilon_2} \times 10 = 2$$

$$\frac{8\varepsilon_1\varepsilon_2}{16\varepsilon_1\varepsilon_2 + 16\varepsilon_1^2} = \frac{1}{5}$$

$$\frac{\varepsilon_2}{2\varepsilon_2 + 2\varepsilon_1} = \frac{1}{5}$$

$$2\varepsilon_2 + 2\varepsilon_1 = 5\varepsilon_2$$

$$2\varepsilon_1 = 3\varepsilon_2$$

$$\frac{\varepsilon_1}{\varepsilon_2} = \frac{3}{2}$$

$$\varepsilon_1 : \varepsilon_2 = 3:2$$

Q. 9 Consider an LTI system with transfer function

$$H(s) = \frac{1}{s(s+4)}$$

If the input to the system is $\cos(3t)$ and the steady state output is $A\sin(3t+\alpha)$, then the value of A is

(A) 1/30 (B) 1/15

(C) 3/4 (D) 4/3

Sol. 9 Correct option is (B).

Let input $x(t) = k\cos 3t,\ k = 1$

$$y(t) = A\sin(3t+\alpha)$$

We can see that output differs only in phase. In Laplace domain

$$Y(s) = X(s)H(s)$$

$$|Y(s)| = |X(s)||H(s)|$$

$$|Y(j\omega)| = |X(j\omega)||H(j\omega)|$$

$$A = 1 \times \frac{1}{\omega\sqrt{\omega^2+16}}$$

For $\omega = 3$, $$A = 1 \times \frac{1}{3\sqrt{9+16}}$$

$$= \frac{1}{15}$$

Q. 10 Consider an LTI system with impulse response $h(t) = e^{-5t}u(t)$. If the output of

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the system is $y(t) = e^{-3t}u(t) - e^{-5t}u(t)$ then the input, $x(t)$, is given by

(A) $e^{-3t}u(t)$ (B) $2e^{-3t}u(t)$

(C) $e^{-5t}u(t)$ (D) $2e^{-5t}u(t)$

Sol. 10 Correct option is (B).

Impulse response $h(t) = e^{-5t}u(t)$

Laplace transform, $H(s) = \dfrac{1}{s+5}$

Output, $y(t) = e^{-3t}u(t) - e^{-5t}u(t)$

Laplace transform, $Y(s) = \dfrac{1}{s+3} + \dfrac{1}{s+5} = \dfrac{2}{(s+3)(s+5)}$

We know that, $Y(s) = X(s)H(s)$

So, $X(s) = \dfrac{Y(s)}{H(s)}$

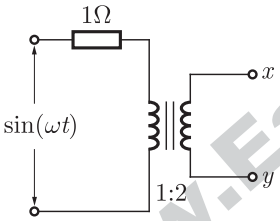
Substituting $Y(s)$ and $H(s)$, we get

$$X(s) = \frac{2}{s+3}$$

Taking inverse Laplace, transform

$$x(t) = 2e^{-3t}u(t)$$

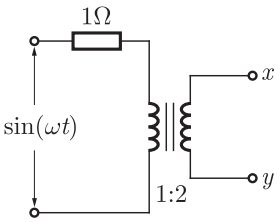
Q. 11 Assuming an ideal transformer, the Thevenin's equivalent voltage and impedance as seen from the terminals x and y for the circuit in figure are



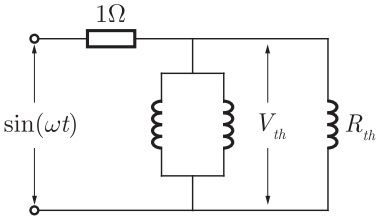
(A) $2\sin(\omega t), 4\,\Omega$ (B) $1\sin(\omega t), 1\,\Omega$

(C) $1\sin(\omega t), 2\,\Omega$ (D) $2\sin(\omega t), 0.5\,\Omega$

Sol. 11 Correct option is (A).



Referring to secondary side



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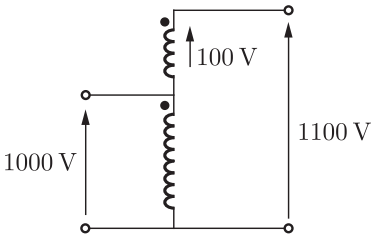
$$V_{Th} = \left(\frac{N_2}{N_1}\right)V_s$$

$$V_{Th} = \frac{2}{1}\sin(\omega t) = 2\sin(\omega t)$$

$$R_{Th} = \left(\frac{2}{1}\right)^2 R_P$$

$$= \left(\frac{2}{1}\right)^2 R_P = 4 \times 1 = 4\,\Omega$$

Q. 12 A single phase, 50 kVA, 1000 V/100 V two winding transformer is connected as an autotransformer as shown in the figure.



The kVA rating of the autotransformer is _____.

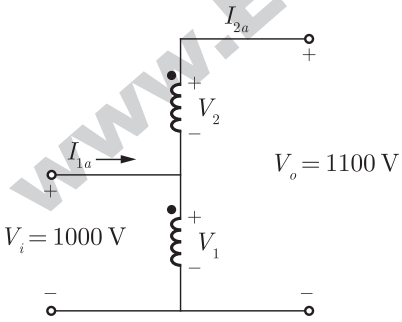
Sol. 12 Correct answer is 550.

From the given information for the two winding transformer, we have

$$V_1 = 1000\text{ V},\ V_2 = 100\text{ V},\ S_0 = 50\text{ kVA}$$

So, $I_1 = 50\text{ A},\ I_2 = 500\text{ A}$

For the autotransformer as shown in figure



$$V_i = V_1 = 1000\text{ V}$$

$$V_o = V_1 + V_2 = 1000 + 100 = 1100\text{ V}$$

Rating of auto transformer

$$S_{0a} = V_0 \times I_{2a} \qquad (I_{2a} = I_2)$$

$$= 1100 \times 500 = 550\text{ kVA}$$

Q. 13 A three-phase, 4-pole, self excited induction generator is feeding power to a load at a frequency f_1. If the load is partially removed, the frequency becomes f_2. If the speed of the generator is maintained at 1500 rpm in both the cases, then

(A) $f_1,\ f_2 > 50$ Hz and $f_1 > f_2$ (B) $f_1 < 50$ Hz and $f_2 > 50$ Hz

(C) $f_1,\ f_2 < 50$ Hz and $f_2 > f_1$ (D) $f_1 > 50$ Hz and $f_2 < 50$ Hz

Sol. 13 Correct option is (C).

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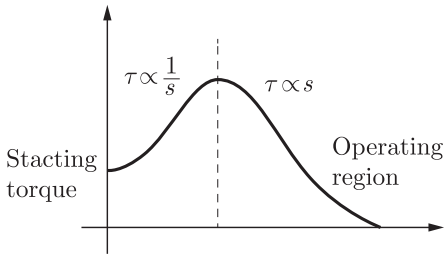

As the load decreases, the speed increases. Relative speed between stator rmf and rotor speed reduced which decrease the slip consequently emf induced in the rotor and current decreases. Hence frequency decreases.

So $$f_1, f_2 < 50\ \text{Hz}$$

but $$f_2 > f_1$$

Q. 14 A single phase induction motor draws 12 MW power at 0.6 lagging power. A capacitor is connected in parallel to the motor to improve the power factor of the combination of motor and capacitor to 0.8 lagging. Assuming that the real and reactive power drawn by the motor remains same as before, the reactive power delivered by the capacitor in MVAR is _ _ _ _ _ _.

Sol. 14 Correct answer is 7.

Let complex power (kVA) is given as

$$S = P + jQ$$

$$P \rightarrow \text{Real power } (W)$$

$$Q \rightarrow \text{Reactive Power } (VR)$$

Real power $$P = |S| \cos\theta$$

Reactive power $$Q = |S| \sin\theta$$

or $$Q = \frac{P}{\cos\theta} \sin\theta = P \tan\theta$$

Initially when the real power is 12 MW and power factor is 0.6, the reactive power is

$$Q_1 = P_1 \tan\theta_1$$

$$= 12 \tan(53.13^\circ) \qquad \theta = \cos^{-1}(0.6) = 53.13^\circ$$

$$= 12 \times \frac{4}{3} = 16\ \text{MVR}$$

Now, when capacitor is added, improved power factor angle

$$Q_2 = \cos^{-1}(0.80) = 36.86^\circ$$

Total reactive power after adding capacitor

$$Q_2 = P_1 \tan\theta_2 \qquad (P_1 \text{ is same})$$

$$Q_2 = 12 \times \tan(36.86^\circ)$$

$$= 12 \times \frac{3}{4} = 9\ \text{MAR}$$

From the power triangle (before and after capacitor is added)

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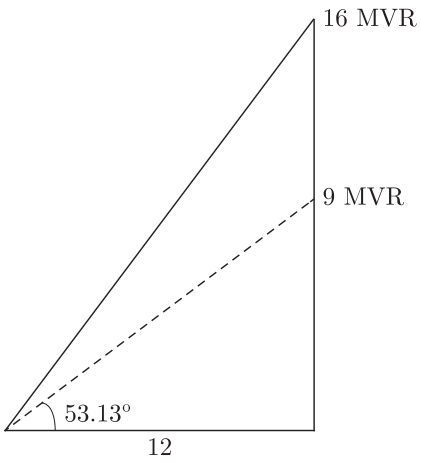

Reactive power delivered by capacitor

$$Q_C = Q_1 - Q_2$$
$$= 16 - 9 = 7 \text{ MVR}$$

Q. 15 A three phase star-connected load is drawing power at a voltage of 0.9 pu and 0.8 power factor lagging. The three phase base power and base current are 100 MVA and 437.38 A respectively. The line-to-line load voltage in kV is _ _ _ _ _.

Sol. 15 Correct answer is 118.80 .

$$\text{p.u. value} = \frac{\text{Acual value in same units}}{\text{Base value in same units}}$$

$$\text{Base voltage} = \frac{\text{Base MVA}}{\text{Base Current}}$$

$$\text{Base voltage} = \frac{100 \times 10^6}{437.38 \text{ A}} = 228.63 \text{ kV}$$

$$0.9 \text{ p.u.} = \frac{\text{Actual value}}{228.63 \text{ kV}}$$

$$V_{\text{actual}} = 228.63 \times 0.9 \text{ kV} = 205.77 \text{ kV}$$

As load is star connected

$$V_{L-L} = \frac{V_{\text{acutal}}}{\sqrt{3}} = \frac{205.77 \text{ kV}}{\sqrt{3}}$$
$$V_{L-L} = 118.80 \text{ kV}$$

Q. 16 Shunt reactors are sometimes used in high voltage transmission systems to

(A) limit the short circuit current through the line

(B) compensate for the series reactance of the line under heavily loaded condition

(C) limit over-voltages at the load side under lightly loaded condition.

(D) compensate for the voltage drop in the line under heavily loaded condition.

Sol. 16 Correct option is (C).

Shunt reactors are used in high voltage transmission system to limit over voltages at the load side under lightly loaded condition.

Q. 17 The closed-loop transfer function of a system is $T(s) = \frac{4}{(s^2 + 0.4s + 4)}$. The steady state error due to unit step input is _ _ _ _ _.

Sol. 17 Correct answer is 0.

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Closed loop T.F.

$$T(s) = \frac{4}{s^2 + 0.4s + 4}$$

$$\frac{G(s)}{1+G(s)} = \frac{4}{s^2 + 0.4s + 4}$$

$$\frac{1+G(s)}{G(s)} = \frac{s^2 + 0.4s + 4}{4}$$

$$1 + \frac{1}{G(s)} = \frac{s^2 + 0.4s + 4}{4}$$

$$\frac{1}{G(s)} = \frac{s^2 + 0.4s + 4 - 4}{4}$$

Open loop. T.F. $G(s) = \dfrac{4}{s(s+0.4)}$

Error constant, $K_p = \lim_{s \to 0} G(s)$

$$= \lim_{s \to 0} \frac{4}{s(s+0.4)} = \infty$$

Steady state error $e_{ss} = \dfrac{1}{1+K_p} = 0$

Q. 18 The state transition matrix for the system $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u$ is

(A) $\begin{bmatrix} e^t & 0 \\ e^t & e^t \end{bmatrix}$ (B) $\begin{bmatrix} e^t & 0 \\ t^2 e^t & e^t \end{bmatrix}$

(C) $\begin{bmatrix} e^t & 0 \\ te^t & e^t \end{bmatrix}$ (D) $\begin{bmatrix} e^t & te^t \\ 0 & e^t \end{bmatrix}$

Sol. 18 Correct option is (C).

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} U$$

$$Y = AX + BU$$

State transmission matrix

$$\phi(t) = \mathcal{L}^{-1}(sI - A)^{-1}$$

$$[SI - A] = \begin{bmatrix} s-1 & 0 \\ 1 & s-1 \end{bmatrix}$$

So, $\phi(t) = \mathcal{L}^{-1} \dfrac{1}{(s-1)^2} \begin{bmatrix} s-1 & 0 \\ 1 & s-1 \end{bmatrix}$

$$= \mathcal{L}^{-1} \begin{bmatrix} \frac{1}{s-1} & 0 \\ \frac{1}{(s-1)^2} & \frac{1}{s-1} \end{bmatrix}$$

$$\phi(t) = \begin{bmatrix} e^t & 0 \\ te^t & e^t \end{bmatrix}$$

Q. 19 The saw-tooth voltage waveform shown in the figure is fed to a moving iron voltmeter. Its reading would be close to _ _ _ _ _ _ _ _ _ _

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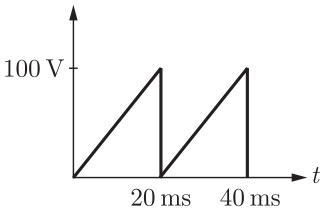

Sol. 19 Correct answer is 57.74 .

From the graph, we write mathematical expression of voltage $v(t)$

$$v(t) = \frac{100}{20 \times 10^{-3}} t,$$

So, $$v(t) = 5 \times 10^{3} t \text{ Volt},$$

A moving iron voltmeter reads rms value of voltage, so

$$V_{rms} = \sqrt{\frac{1}{T}\int_0^T v^2(t)dt}$$

$$= \sqrt{\frac{1}{20 \times 10^{-3}}\int_0^{20\times10^{-3}} (5 \times 10^3 \times t)^2 dt}$$

$$= \sqrt{\frac{25 \times 10^6}{20 \times 10^{-3}}\int_0^{20\times10^{-3}} t^2 dt}$$

$$= \sqrt{\frac{25 \times 10^6}{20 \times 10^{-3}}\left[\frac{t^3}{3}\right]_0^{20\times10^{-3}}}$$

$$= \sqrt{\frac{25 \times 10^6}{20 \times 10^{-3}} \times \frac{(20 \times 10^{-3})^3}{3}}$$

$$= \sqrt{\frac{25 \times 10^6 \times 400 \times 10^{-6}}{3}}$$

$$= \frac{100}{\sqrt{3}} = 57.74 \text{ A}$$

Q. 20 While measuring power of a three-phase balanced load by the two-wattmeter method, the readings are 100 W and 250 W. The power factor of the load is _ _ _ _ _ _.

Sol. 20 Correct answer is 0.8029.

In two wattmeter method, power factor angle is given by

$$\phi = \tan^{-1}\left[\frac{\sqrt{3}(W_1 - W_2)}{W_1 + W_2}\right]$$

$$= \frac{\sqrt{3}(250 - 100)}{250 + 100}$$

$$\phi = \tan^{-1}(0.7423)$$

$$\phi = 36.586^\circ$$

$$\text{Power factor} = \cos\phi$$

$$= \cos(36.586^\circ) = 0.8029 \text{ lagging}$$

Q. 21 Which of the following is an invalid state in an 8-4-2-1 Binary Coded Decimal counter

(A) 1 0 0 0 (B) 1 0 0 1

(C) 0 0 1 1 (D) 1 1 0 0

Sol. 21 Correct option is (D).

8-4-2-1 Binary coded decimal counter valid as long as the value is less than 9 or

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equal to 9.

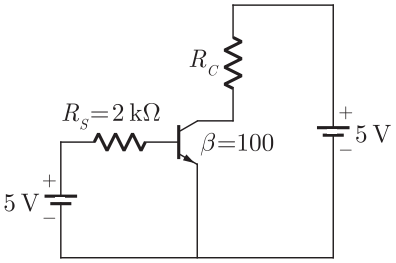
(A) $1000 = 8 \leq 9$

(B) $1001 = 9 \leq 9$

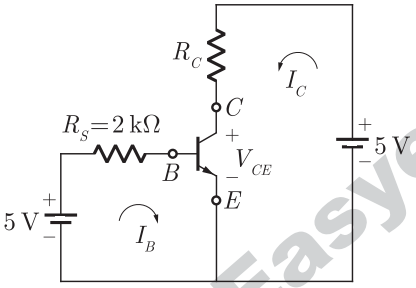
(C) $0011 = 3 \leq 9$

(D) $1100 = 12 > 9$ Invalid

Q. 22 The transistor in the given circuit should always be in active region. Take $V_{CE(sat)} = 0.2\,\text{V}$, $V_{BE} = 0.7\,\text{V}$. The maximum value of R_c in Ω which can be used, is _ _ _ _ _.



Sol. 22 Correct answer is 22.38 .



Given: $V_{CE(\text{sat})} = 0.2$

$V_{BE} = 0.7$

$\beta = 100$

Writing KVL around the input loop

$$5 - I_B R_S - 0.7 = 0$$

$$I_B = \frac{5 - 0.7}{2\,\text{k}\Omega} = \frac{4.3}{2 \times 10^3} = 2.15\,\text{mA}$$

$$I_C = \beta I_B = 100 \times 2.15\,\text{mA} = 0.215\,\text{A}$$

Writing KVL around the output loop

$$5 - I_C R_C - V_{CE} = 0$$

$$V_{CE} = 5 - 0.215 R_C$$

For active region $V_{CE} > V_{CE(\text{sat})}$

or, $V_{CE} > 0.2\,\text{V}$

So, $5 - 0.215 R_C > 0.2$

$$0.215 R_C < 5 - 0.2$$

$$R_{C\min} = \frac{4.8}{0.215} \approx 22.32\,\Omega$$

Q. 23 The sinusoidal ac source in the figure has an rms value of $\frac{20}{\sqrt{2}}$ V. Considering all possible values of R_L, the minimum value of R_s in Ω to avoid burnout of the Zener diode is _ _ _ _ _.

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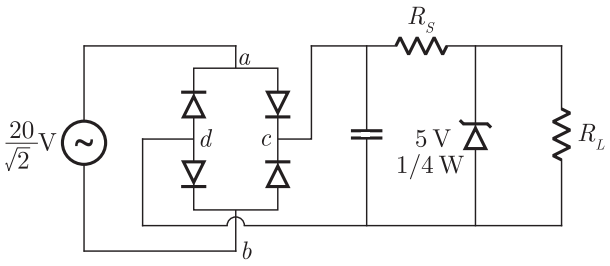
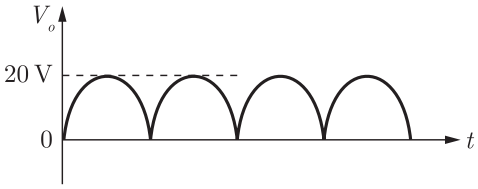
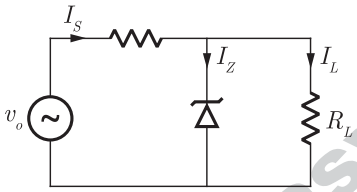


Sol. 23 Correct answer is 300.

The given circuit is a bridge full wave rectifier with zener regulator. The voltage across the regulator is a full wave rectified output as shown below.





$$I_S = I_Z + I_L$$

$$I_Z = I_S - I_L$$

$$I_{Z\max} = I_{S\max} - I_{L\min} \quad \text{...(i)}$$

Because when I_L will be minimum I_Z will be maximum.

We have

$$I_{S\max} = \frac{V_o - V_Z}{R_{s\min}} = \frac{20-5}{R_{s\min}}$$

$$I_{L\min} = 0 \qquad (\text{for } R_L \to \infty)$$

$$I_{Z\max} = \frac{P_Z}{V_Z} = \frac{(1/4)}{5} = \frac{1}{20}\text{ A}$$

Substituting these values in eq (i), we get

$$\frac{1}{20} = \frac{20-5}{R_{s\min}}$$

$$R_{s\min} = 15 \times 20 = 300\,\Omega$$

Q. 24 A step-up chopper is used to feed a load at 400 V dc from a 250 V dc source. The inductor current is continuous. If the 'off' time of the switch is 20 μs, the switching frequency of the chopper in kHz is _____.

Sol. 24 Correct answer is 31.2 .

As step up chopper

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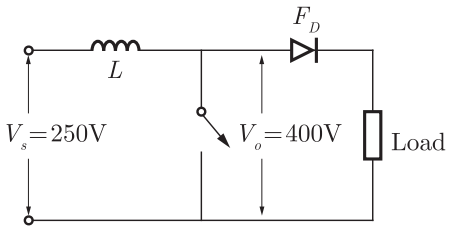

In step-up chopper output voltage is given by

$$V_o = \frac{V_s}{1-\alpha} \qquad \text{where } \alpha \text{ is duty cycle } \alpha = \frac{T_{ON}}{T}$$

$$1-\alpha = \frac{V_s}{V_o} = \frac{250}{400}$$

$$1-\alpha = \frac{5}{8} \Rightarrow \alpha = 3/8$$

So,
$$\frac{T_{ON}}{T} = \frac{3}{8}$$

$$\frac{T - T_{OFF}}{T} = \frac{3}{8} \qquad (T = T_{ON} + T_{OFF})$$

$$1 - \frac{T_{OFF}}{T} = \frac{3}{8}$$

$$\frac{T_{OFF}}{T} = \frac{5}{8} \qquad \text{where, } T_{OFF} = 20\,\mu\text{s and } T = \frac{1}{f}\text{ Hz}$$

So,
$$f \times 20 \times 10^{-6} = \frac{5}{8}$$

$$f = \frac{5}{8 \times 20 \times 10^{-6}} = 31.2\text{ kHz}$$

Q. 25 In a constant V/f control of induction motor, the ratio V/f is maintained constant from 0 to base frequency, where V is the voltage applied to the motor at fundamental frequency f. Which of the following statements relating to low frequency operation of the motor is TRUE ?

(A) At low frequency, the stator flux increases from its rated value.

(B) At low frequency, the stator flux decreases from its rated value.

(C) At low frequency, the motor saturates.

(D) At low frequency, the stator flux remains unchanged at its rated value.

Sol. 25 Correct option is (B).

$$\frac{V}{f} = \text{Constant}$$

At low frequency the stator plan decrease from its rated value as at low frequency will increase the flux density which results in saturation of stator are therefore stator flux decreases.

Q. 26 - Q. 55 Carry two marks each.

Q. 26 To evaluate the double integral $\int_0^8 \left(\int_{y/2}^{(y/2)+1} \left(\frac{2x-y}{2} \right) dx \right) dy$, we make the substitution

$u = \left(\frac{2x-y}{2}\right)$ and $v = \frac{y}{2}$. The integral will reduce to

(A) $\int_0^4 \left(\int_0^2 2u\,du \right) dv$ (B) $\int_0^4 \left(\int_0^1 2u\,du \right) dv$

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(C) $\int_0^4\left(\int_0^1 u\,du\right)dv$ (D) $\int_0^4\left(\int_0^2 u\,du\right)dv$

Sol. 26 Correct option is (B).

$$\int_0^8\left(\int_{y/2}^{\frac{y}{2}+1}\left(\frac{2x-y}{2}\right)dx\right)dy = ?$$

$$\frac{2x-y}{2} = u \Rightarrow x = x-\frac{y}{2} = u$$

$$dx = du$$

At $x=\frac{y}{2}$ $\quad u = \frac{2\times y/2-y}{2} = 0$

at $x=\frac{y}{2}+1$ $\quad u = \frac{2\left(\frac{y}{2}+1\right)-y}{2} = 1$

Thus integral becomes $\int_0^8\left[\int_0^1 u\,du\right]dy$

$$v = \frac{y}{2}$$

$$dv = \frac{dy}{2} \Rightarrow dy = 2dv$$

at $y=0 \Rightarrow \quad v = 0$

at $y=8 \Rightarrow \quad v = 4$

$$= \int_0^4\left[\int_0^1 u\,du\right]2dv$$

Reduced form $= \int_0^4\left[\int_0^1 2u\,du\right]dv$

Q. 27 Let X be a random variable with probability density function

$$f(x) = \begin{cases} 0.2, & \text{for } |x| \le 1 \\ 0.1, & \text{for } 1 < |x| \le 4 \\ 0, & \text{otherwise} \end{cases}$$

The probability $P(0.5 < X < 5)$ is _____.

Sol. 27 Correct answer is 0.4 .

$$f(x) = \begin{cases} 0.2 & \text{for } |x| \le 1 \\ 0.1 & \text{for } 1 < |x| \le 4 \\ 0 & \text{otherwise} \end{cases}$$

$$f(x) = \begin{cases} 0.2 & x = (-1,1) \\ 0.1 & x = (-4,-1)\cup(1,4) \\ 0 & \text{otherwise} \end{cases}$$

on solving inequalities

$$\text{Probability } (P) = \int_{-\infty}^{\infty} f(x)dx$$

$$= \int_{0.5}^{1} 0.2dx + \int_1^4 0.1dx$$

$$= 0.2\times 0.5 + 0.1\times 3$$

$$P = 0.1 + 0.3 = 0.4$$

Q. 28 The minimum value of the function $f(x) = x^3 - 3x^2 - 24x + 100$ in the interval $[-3, 3]$ is

(A) 20 (B) 28

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(C) 16 (D) 32

Sol. 28 Correct option is (B).

$$f(x) = x^3 - 3x^2 - 24x + 100 \text{ on } [-3, 3]$$

The given function is a polynomial and so continuous everywhere. Now we get derivative of the function to option the critical points

$$f'(x) = 3x^2 - 6x - 24$$

or
$$x^2 - 2x - 8 = 0$$
$$x^2 - 4x + 2x - 8 = 0$$
$$x(x-4) + 2(x-4) = 0$$
$$(x-4)(x+2) = 0$$

So, $x = 4$ and $x = -2$

We consider the critical point that actually fall in the given interval. So we only take $x = -2$. Now, we find the function value at the critical point $x = -2$ and end points $x = -3$, $x = 3$.

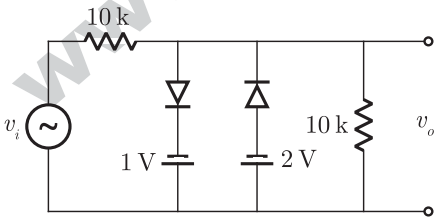
$$f(-2) = (-2)^3 - 3(-2)^2 - 24(-2) + 100$$
$$f(-2) = 128$$
$$f(-3) = (-3)^3 - 3(-3)^2 - 24(-3) + 100$$
$$f(-3) = 172$$
$$f(3) = (3)^3 - 3(3)^2 - 24(3) + 100$$
$$f(3) = 28$$

We have

$$f(-2) = 128,\ f(-3) = 172,\ f(3) = 28$$

From list of above values we can see that absolute minimum is 28 which occurs at $x = 3$.

Q. 29 Assuming the diodes to be ideal in the figure, for the output to be clipped, the input voltage v_i must be outside the range

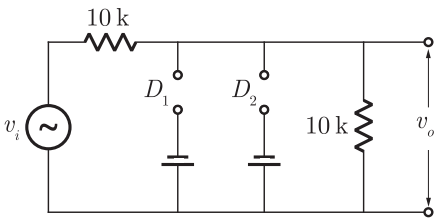


(A) -1 V to -2 V (B) -2 V to -4 V

(C) $+1$ V to -2 V (D) $+2$ V to -4 V

Sol. 29 Correct option is (B).

Assume when both the diodes will be OFF.



In that case

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$$v_o = \frac{v_i}{2}$$

For proper clipping operation, both the diode can not be forward biased together. When both diodes are off, we have

$$v_o = \frac{v_i}{2}$$

Let v_{p1}, v_{n1} are voltage of anode and cathode of diode D_1 and v_{p2} and v_{n2} are voltage of anode and cathode of D_2. So

$$v_o = v_{p1} = \frac{v_i}{2}$$

$$v_o = v_{n1} = \frac{v_i}{2}$$

To make both diodes forward biased

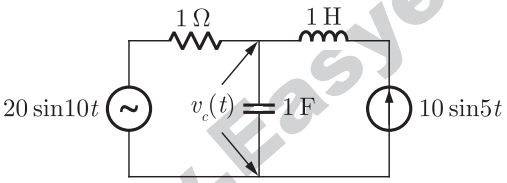
$$v_{p1} > -1\,\text{V} \text{ and } v_{n2} < -2\,\text{V}$$

or $$\frac{v_i}{2} > -1\,\text{V} \text{ and } \frac{v_i}{2} < -2\,\text{V}$$

So $v_i = -2\,\text{V}$ to $-4\,\text{V}$ range does not allow proper clipping operation.

Q. 30 The voltage across the capacitor, as shown in the figure, is expressed as

$$v_c(t) = A_1\sin(\omega_1 t - \theta_1) + A_2\sin(\omega_2 t - \theta_2)$$



The values of A_1 and A_2 respectively, are

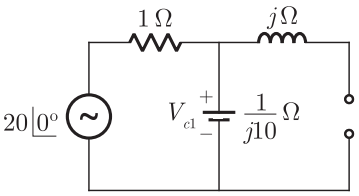
(A) 2.0 and 1.98 (B) 2.0 and 4.20

(C) 2.5 and 3.50 (D) 5.0 and 6.40

Sol. 30 Correct option is (A).

Since there are two sources with different frequencies ($\omega_1 = 10$, $\omega_2 = 5$), we use superposition to obtain $v_C(t)$.

First consider source $v(t) = 20\sin 10t$. Open circuit current source and redrawing circuit in domain with $\omega_1 = 10\,\text{rad/sec}$.



$$V_{C1} = \frac{\frac{1}{j10}}{1+\frac{1}{j10}} \times 20 \qquad \text{(Using voltage division)}$$

$$= \frac{1}{1+j10} \times 20$$

$$V_{C1} = \frac{20}{\sqrt{101}} \angle -\tan^{-1}10$$

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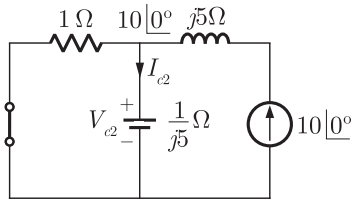
$$A_1 = |V_{C1}| = \frac{20}{\sqrt{101}} = 1.99\ \text{A}$$

Now, consider current source $i(t) = 10\sin 5t$. Short circuit voltage source and redrawing circuit in frequency domain with $\omega_2 = 5\ \text{rad/sec}$.



$$I_{C2} = \frac{1}{1+\frac{1}{j5}} 10\angle 0^\circ \qquad \text{(Using current division)}$$

$$= \frac{j5}{1+j5} \times 10\angle 0^\circ$$

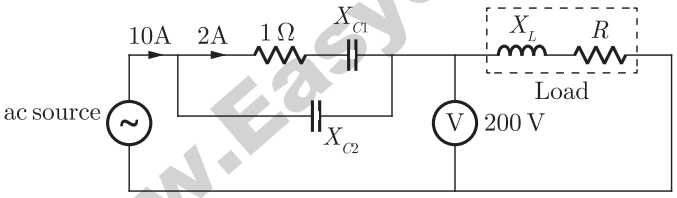
$$V_{C2} = I_{C2} \times \frac{1}{j5}$$

$$V_{C2} = \frac{10\angle 0^\circ}{1+j5}$$

$$V_{C2} = \frac{10}{\sqrt{26}}\angle -\tan^{-5}$$

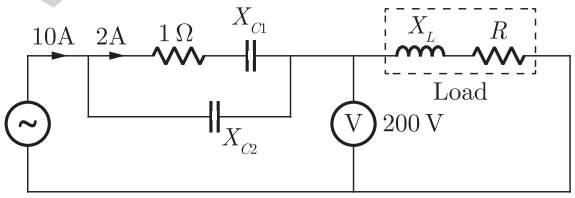
$$A_2 = |V_{C2}| = \frac{10}{\sqrt{26}} = 1.96\ \text{A}$$

Q. 31 The total power dissipated in the circuit, shown in the figure, is 1 kW.



The voltmeter, across the load, reads 200 V. The value of X_L is _____.

Sol. 31 Correct answer is 17.34 .



Total power consumed, $P = 1\,\text{KW} = 1000\ \text{W}$

We can see that power will be consumed by only $1\,\Omega$ resistor and load resistor R. From the figure we can notice that current in $1\,\Omega$ resistor is 2 A and in load resistor R is 10 A. So we can write total power equal to sum of power dissipated in these two resistors.

$$P = (2)^2(1) + (10)^2 R$$

$$1000 = 4 + 100R$$

$$R = 9.96\,\Omega$$

Voltage across load, $|V_L| = 200\ \text{V}$

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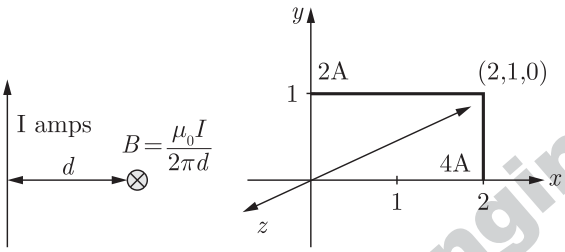
$$
\begin{aligned}
|V_L| &= I\sqrt{R^2 + X_L^2} \\
200 &= 10\sqrt{(9.96)^2 + X_L^2} \\
(20)^2 &= (9.96)^2 \times X_L^2 \\
X_L &= \sqrt{400 - 99.20} \\
X_L &= 17.34\,\Omega
\end{aligned}
$$

Q. 32 The magnitude of magnetic flux density (B) at a point having normal distance d meters from an infinitely extended wire carrying current of I A is $\frac{\mu_0 I}{2\pi d}$ (in SI units). An infinitely extended wire is laid along the x-axis and is carrying current of 4 A in the $+$ve x direction. Another infinitely extended wire is laid along the y axis and is carrying 2 A current in the $+$ve y direction. μ_0 is permeability of free space. Assume i, j, k to be unit vectors along x, y and z axes respectively.

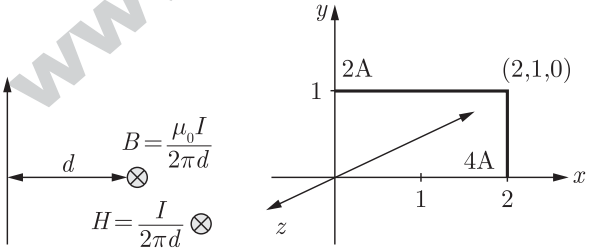


Assuming right handed coordinate system, magnetic field intensity, H at coordinate $(2,1,0)$ will be

(A) $\frac{3}{2\pi}k$ weber/m^2 (B) $\frac{4}{3\pi}i$ A/m

(C) $\frac{3}{2\pi}k$ A/m (D) 0 A/m

Sol. 32 Correct option is (C).



$$
\begin{aligned}
H \text{ by wire on } x\text{-axis} &= \frac{I}{2\pi d}k \\
&= \frac{4}{1} \times \frac{1}{2\pi}k \\
H \text{ by wire on } y\text{-axis} &= \frac{I}{2\pi d}(-k) \\
&= \frac{2}{2} \times \frac{1}{2\pi}(-k) \\
H \text{ on } (2,\,1,\,0) &= \frac{4}{2\pi}k - \frac{1}{2\pi}k \\
H &= \frac{3}{2\pi}k \text{ A/m}
\end{aligned}
$$

Q. 33 A discrete system is represented by the difference equation

$$
\begin{bmatrix} X_1(k+1) \\ X_2(k+1) \end{bmatrix} = \begin{bmatrix} a & a-1 \\ a+1 & a \end{bmatrix} \begin{bmatrix} X_1(k) \\ X_2(k) \end{bmatrix}
$$

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It has initial conditions $X_1(0)=1; X_2(0)=0$. The pole locations of the system for $a=1$, are

(A) $1 \pm j0$ (B) $-1 \pm j0$

(C) $\pm 1 + j0$ (D) $0 \pm j1$

Sol. 33 Correct option is (A).

Characteristic equation

$$|zI - A| = 0$$

where $$A = \begin{bmatrix} a & a-1 \\ a+1 & a \end{bmatrix}$$

So, $$zI - A = \begin{bmatrix} z & z \\ 0 & 0 \end{bmatrix} - \begin{bmatrix} a & a-1 \\ a+1 & a \end{bmatrix}$$

$$= \begin{bmatrix} z-a & -a+1 \\ -a-1 & z-a \end{bmatrix}$$

For $a=1$, $$zI - A = \begin{bmatrix} z-1 & 0 \\ -2 & z-1 \end{bmatrix}$$

Characteristic equation

$$|zI - A| = 0$$

$$(z-1)^2 = 0$$

$$z = 1 \pm j0$$

The roots of characteristic equation gives the system poles.

Q. 34 An input signal $x(t) = 2 + 5\sin(100\pi t)$ is sampled with a sampling frequency of 400 Hz and applied to the system whose transfer function is represented by

$$\frac{Y(z)}{X(z)} = \frac{1}{N}\left(\frac{1-z^{-N}}{1-z^{-1}}\right)$$

where, N represents the number of samples per cycle. The output $y(n)$ of the system under steady state is

(A) 0 (B) 1

(C) 2 (D) 5

Sol. 34 Correct option is (C).

Input signal, $$x(t) = 2 + 5\sin(100\pi t)$$

Sample signal, $$x(nT_s) = 2 + 5\sin(100\pi \times nT_s)$$

$T_s \rightarrow$ Sampling period, $T_s = \frac{1}{400}$

$$x(nT_s) = 2 + 5\sin\left(100\pi \times n \times \frac{1}{400}\right)$$

$$x(nT_s) = 2 + 5\sin\left(\frac{n\pi}{4}\right)$$

Transfer function

$$H(z) = \frac{Y(z)}{X(z)} = \frac{1}{N}\left(\frac{1-z^{N}}{1-z^{-1}}\right)$$

$$= \frac{1}{N}\sum_{n=0}^{N-1} z^{-n}$$

or $$h(n) = \begin{cases} \frac{1}{N} & 0 \le n \le N-1 \\ 0 & \text{otherwise} \end{cases}$$

$$N = \frac{f_s}{f} = \frac{400}{50} = 8 \qquad f = \frac{100\pi}{2\pi} = 50 \text{ Hz}$$

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So $$h(n)=\begin{cases}\frac{1}{8} & 0 \le n \le 7\\ 0 & \text{otherwise}\end{cases}$$

$$y(n)=x(n)*h(n)$$

$$x(n)=\left\{2, 2+\frac{5}{\sqrt{2}}, (2+5), \left(2+\frac{5}{\sqrt{2}}\right), 2 \ldots\ldots\right\}$$

By solving the convolution

$$y(n)=\sum_{n=0}^{N-1} x(k)h(n-k)$$

The integration sum of sine term will be zero and for constant term

$$y(n)=\sum_{n=0}^{7} 2 \times \frac{1}{8}=2$$

Q. 35 A 10 kHz even-symmetric square ware is passed through a bandpass filter with centre frequency at 30 kHz and 3 dB passband of 6 kHz. The filter output is

(A) a highly attenuated square wave at 10 kHz

(B) nearly zero

(C) a nearly perfect cosine wave at 30 kHz

(D) a nearly perfect sine wave at 30 kHz

Sol. 35 Correct option is (C).

Q. 36 A 250 V dc shunt machine has armature circuit resistance of $0.6\,\Omega$ and field circuit resistance of $125\,\Omega$. The machine is connected to 250 V supply mains. The motor is operated as a generator and then as a motor separately. The line current of the machine in both the cases is 50 A. The ratio of the speed as a generator to the speed as a motor is _ _ _ _ _.

Sol. 36 Correct answer is 1.27 .

When the machine is running as a generator

Field current $I_{sn}=\frac{250}{120}=2\text{ A}$

Load current $I_L=50\text{ A}$

Armature current $I_a=I_L+I_{sn}=50+2=52\text{ A}$

Induced Emf $E_g=250+52(0.6)=281.2\text{ V}$

When the machine is running as a motor

Field current $I'_{sn}=\frac{250}{125}=2\text{ A}$

Load current $I'_L=50\text{ A}$

Armature current $I'_a=I'_L-I'_{sn}=50-2=48\text{ A}$

Induced Emf $E_m=250-48(0.6)=221.2\text{ V}$

For DC machine, ϕ is constant, so

$$\frac{N_g}{E_g}=\frac{N_m}{E_m}$$

Speed Ratio $$\frac{N_g}{N_m}=\frac{E_g}{E_m}=\frac{281.2}{221.2}=1.27$$

Q. 37 A three phase slip-ring induction motor, provided with a commutator winding, is shown in the figure. The motor rotates in clockwise direction when the rotor windings are closed.

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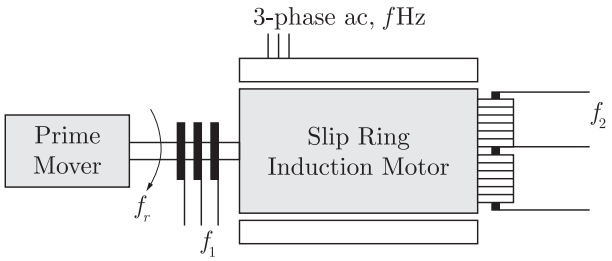

If the rotor winding is open circuited and the system is made to run at rotational speed f_r with the help of prime-mover in anti-clockwise direction, then the frequency of voltage across slip rings is f_1 and frequency of voltage across commutator brushes is f_2. The values of f_1 and f_2 respectively are

(A) $f+f_r$ and f (B) $f-f_r$ and f

(C) $f-f_r$ and $f+f_r$ (D) $f+f_r$ and $f-f_r$

Sol. 37 Correct option is (A).

Given that Rotor winding is open circuit and rotor is rotating anti-clockwise, therefore

Slip $$s = \frac{N_s + N_r}{N_s}$$

or $$f_1 = f_s + f_r = f + f_r$$

So frequency of voltage across slip rings is $(f+f_r)$ Hz.

At the same time, frequency of voltage across commutator brushes is same as rotor frequency

$$f_2 = f$$

Q. 38 A 20-pole alternators is having 180 identical stator slots with 6 conductors in each slot. All the coils of a phase are in series. If the coils are connected to realize single-phase winding, the generated voltage is V_1. If the coils are reconnected to realize three phase star connected winding, the generated phase voltage is V_2. Assuming full pitch, single-layer winding, the ratio V_1/V_2 is

(A) $\frac{1}{\sqrt{3}}$ (B) $\frac{1}{2}$

(C) $\sqrt{3}$ (D) 2

Sol. 38 Correct option is (D).

For single phase winding

no. of coils in the phase

$$n = \frac{180}{20 \times 1} = 9$$

The slop span in electric degree

$$r = \frac{180}{\text{no. of slots per pole}} = \frac{180}{180/20} = 20^\circ$$

Distribution factor $$k_{d1} = \frac{\sin(nr/2)}{n\sin(r/2)}$$

$$= \frac{\sin(9 \times 20/2)}{9 \times \sin(20/2)} = 0.6398$$

No. of turns, $$N_1 = \text{no. of slots} \times \frac{\text{no. of conductors}}{2}$$

$$= \frac{180 \times 6}{2} = 540$$

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Now for three phase winding

Slot span $r = 20^\circ$

No. of coils in a phase group

$$n = \frac{180}{20 \times 3} = 3$$

Distribution factor $k_{d2} = \dfrac{\sin(nr/2)}{n\sin(r/2)}$

$$= \frac{\sin(3 \times 20/2)}{3 \times \sin(20/2)} = 0.9597$$

no. of turns, N_2

$$= \text{no. of slots} \times \frac{\text{no. of conductor}}{2} \times \frac{1}{\text{no. of phase}}$$

$$= 180 \times \frac{6}{2} \times \frac{1}{3}$$

$$= 180$$

The rms value of generator voltage

For single, phase, $V_1 = 4.44\, k_{d1} \phi f N_1$

For three phase, $V_2 = 4.44 k_{d2} \phi f N_2$

$$\frac{V_1}{V_2} = \frac{k_{d1} \times N_1}{k_{d2} \times N_2}$$

$$= \frac{0.6398 \times 540}{0.9597 \times 180}$$

$$\simeq 2$$

Q. 39 For a single phase, two winding transformer, the supply frequency and voltage are both increased by 10%. The percentage changes in the hysteresis loss and eddy current loss, respectively, are

(A) 10 and 21 (B) -10 and 21

(C) 21 and 10 (D) -21 and 10

Sol. 39 Correct option is (A).

Hysteris loss in transformer

$$P_h = k_n f B_{\max}^n$$

Where, the k_n is the proportionality constant dependent on the characteristics and volume of material, n is known as steinmetz exponents.

$$B_{\max} \propto \frac{V}{f}$$

Change in voltage and frequency is same, so $B_{\max}$ is constant.

So, $P_h \propto f$

Change in voltage and frequency is same, so $B_{\max}$ is constant.

So, $P_h \propto f$

Therefore percentage change in hysteris loss will be same as that of change in frequency

$$\Delta P_h = \Delta f = 10\%$$

Eddy current loss is given by

$$P_e = k_e (B_{\max} f \delta)^2$$

Where

δ = lamination thickness

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B_{max} = maximum flux density

f = frequency

k_e = Proportionality constant

Again, $B_{max} \propto \frac{V}{f}$ (Constant)

So, $P_e \propto f^2$

$$\frac{P_{e1}}{P_{e2}} = \frac{f_1^2}{f_2^2}$$

$$\frac{f_1}{f_2} = \frac{f}{f+0.1f} = \frac{1}{1.1}$$

So $$\frac{P_{e1}}{P_{e2}} = \left(\frac{1}{1.1}\right)^2$$

or $$P_{e2} = (1.1)^2 P_{e1}$$

$$P_{e2} = 1.21 P_{e1}$$

Now, percentage change in eddy current loss

$$\Delta P_e = \frac{P_{e2} - P_{e1}}{P_{e1}} \times 100 = \frac{1.21 - 1}{1} \times 100$$

$$= 21\%$$

Q. 40 A synchronous generator is connected to an infinite bus with excitation voltage $E_f = 1.3$ pu. The generator has a synchronous reactance of 1.1 pu and is delivering real power (P) of 0.6 pu to the bus. Assume the infinite bus voltage to be 1.0 pu. Neglect stator resistance. The reactive power (Q) in pu supplied by the generator to the bus under this condition is _ _ _ _ _.

Sol. 40 Correct answer is 0.1092 .

As active power in synchronous generator is given by

$$P = \frac{E_f V}{X_s} \sin\delta$$

$\delta =$ Load angle

$$0.6 = \frac{1.3 \times 1}{1.1} \sin\delta \qquad \{E_f = 1.3 \text{ pu}, V = 1 \text{ pu}, X_s = 1.1 \text{ pu}, P = 0.6 \text{ pu}\}$$

$$\sin\delta = \frac{0.6 \times 1.1}{1.3 \times 1}$$

$$\sin\delta = 0.5077$$

$$\delta = 30.504^\circ$$

Reactive power is given by

$$Q = \frac{E_f V}{X_s} \cos\delta - \frac{V^2}{X_s}$$

$$= \frac{1.3 \times 1}{1.1} \cos(30.504^\circ) - \frac{1^2}{1.1}$$

$$Q = 1.1818 \times 0.8616 - 0.9090$$

$$Q = 0.1092 \text{ pu}$$

Q. 41 There are two generators in a power system. No-load frequencies of the generators are 51.5 Hz and 51 Hz, respectively, and both are having droop constant of 1 Hz/MW. Total load in the system is 2.5 MW. Assuming that the generators are operating under their respective droop characteristics, the frequency of the power

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system in Hz in the steady state is _ _ _ _ _ _.

Sol. 41 Correct answer is 50.

Since the generators are in parallel, they will operate at the same frequency (f) at steady loss. Let load on generator G_1 is P_1 and on G_2 is P_2. Then we can write for generator G_1

$$\frac{51.5-f}{P_1} = \text{droop constant}$$

$$\frac{51.5-f}{P_1} = 1$$

$$51.5-f = P_1 \quad \text{...(i)}$$

Now in steady state total load is 2.5 MW, so load by second generator is $(2.5-P_1)$. For G_2 we write

$$\frac{51-f}{2.5-P_1} = 1$$

$$51-f = 2.5-P_1 \quad \text{...(ii)}$$

Adding eq (i) and (ii), we get

$$51.5-f+51-f = P_1+2.5-P_1$$

$$102.5-2f = 2.5$$

$$2f = 100$$

$$f = 50 \text{ Hz}$$

Q. 42 The horizontally placed conductors of a single phase line operating at 50 Hz are having outside diameter of 1.6 cm, and the spacing between centers of the conductors is 6 m. The permittivity of free space is 8.854×10^{-12} F/m. The capacitance to ground per kilometer of each line is

(A) 4.2×10^{-9} F (B) 8.4×10^{-9} F

(C) 4.2×10^{-12} F (D) 8.4×10^{-12} F

Sol. 42 Correct option is (B).

$$C = \frac{2\pi\varepsilon_0}{\ln\left(\frac{d_2}{d_1}\right)}$$

$d_2 =$ distance b/w two sphere, $d_1 =$ radius of first sphere

$$= \frac{2 \times \pi \times 8.85 \times 10^{-12}}{\ln\left(\frac{600}{0.8}\right)}$$

$$C = 8.39 \times 10^{-12} \text{ F/m}$$

$$C = 8.39 \times 10^{-12} \times 10^{-3} \text{ F}$$

$$C_{eq} \approx 8.4 \times 10^{-9} \text{ F}$$

Q. 43 A three phase, 100 MVA, 25 kV generator has solidly grounded neutral. The positive, negative, and the zero sequence reactances of the generator are 0.2 pu, 0.2 pu and 0.05 pu, respectively, at the machine base quantities. If a bolted single phase to ground fault occurs at the terminal of the unloaded generator, the fault current in amperes immediately after the fault is_ _ _ _ _.

Sol. 43 Correct answer is 15403.698 .

For single line-to-ground fault, the symmetrical component of current (in pu)

$$I_{a1} = \frac{E_{a1}}{z_0+z_1+z_2} = \frac{1}{0.2+0.2+0.05} = 2.22 \text{ pu}$$

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The magnitude of fault current

$$I_f = 3I_{a1} = 3 \times 2.22 = 6.67 \text{ pu}$$

Base value of current

$$I_{base} = \frac{100 \times 10^6}{\sqrt{3} \times 25 \times 10^3} = 2309.40 \text{ A}$$

So actual value of fault current

$$I_f = 6.67 \times 2309.40$$
$$= 15403.698 \text{ A}$$

Q. 44 A system with the open loop transfer function

$$G(s) = \frac{K}{s(s+2)(s^2+2s+2)}$$

is connected in a negative feedback configuration with a feedback gain of unity. For the closed loop system to be marginally stable, the value of K is _ _ _ _ _ _

Sol. 44 Correct answer is 5.

$$G(s) = \frac{K}{s(s+2)(s^2+2s+2)}$$

$$\text{Closed loop T.F.} = \frac{G(s)}{1+G(s)}$$

$$= \frac{\dfrac{K}{s(s+2)(s^2+2s+2)}}{1+\dfrac{K}{s(s+2)(s^2+2s+2)}}$$

$$\text{Closed loop T.F.} = \frac{K}{s(s+2)(s^2+2s+2)+K}$$

Characteristics equation

$$s(s+2)(s^2+2s+2)+K = 0$$
$$(s^2+2s)(s^2+2s+2)+K = 0$$
$$s^4+4s^3+4s^2+4s+K = 0$$

Routh array

s^4	1	6	k
s^3	4	4	0
s^2	5	k	0
s^1	$\frac{20-4k}{5}$	0	
s^0	k		

For marginally stable

$$20 - 4k = 0$$

or

$$k = 5$$

Q. 45 For the transfer function

$$G(s) = \frac{5(s+4)}{s(s+0.25)(s^2+4s+25)}$$

The values of the constant gain term and the highest corner frequency of the Bode plot respectively are

(A) 3.2, 5.0 (B) 16.0, 4.0

(C) 3.2, 4.0 (D) 16.0, 5.0

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Sol. 45 Correct option is (A).

$$G(s) = \frac{5(s+4)}{(s+0.25)(s^2+4s+25)}$$

$$= \frac{5\times 4}{0.25\times 25}\frac{(1+s/4)}{\left(1+\frac{s}{0.25}\right)\left(1+\frac{4s}{25}+\frac{s^2}{25}\right)}$$

$$= 3.2\times \frac{(1+s/4)}{\left(1+\frac{s}{0.25}\right)\left(1+\frac{4s}{25}+\frac{s^2}{25}\right)}$$

So constant gain term, $K = 3.2$

Highest corner frequency $\omega_H = 5$

Q. 46 The second order dynamic system

$$\frac{dX}{dt} = PX + Qu$$

$$y = RX$$

has the matrices P, Q and R as follows :

$$P = \begin{bmatrix} -1 & 1 \\ 0 & -3 \end{bmatrix} \quad Q = \begin{bmatrix} 0 \\ 1 \end{bmatrix} \quad R = [0\ \ 1]$$

The system has the following controllability and observability properties:

(A) Controllable and observable

(B) Not controllable but observable

(C) Controllable but not observable

(D) Not controllable and not observable

Sol. 46 Correct option is (C).

For controllability, we check controllability matrix

$$C_M = [B\ \ AB]$$

or,
$$C_M = [Q\ \ PQ]$$

$$PQ = \begin{bmatrix} -1 & 1 \\ 0 & -3 \end{bmatrix}\begin{bmatrix} 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 1 \\ -3 \end{bmatrix}$$

So,
$$C_M = \begin{bmatrix} 0 & 1 \\ 1 & -3 \end{bmatrix}$$

$$\det(C_M) = -1 \neq 0$$

So, the system is controllable.

For observability, we check observability matrix

$$O_M = \begin{bmatrix} C \\ CA \end{bmatrix}$$

or
$$O_M = \begin{bmatrix} R \\ RP \end{bmatrix}$$

$$RP = [0\ \ 1]\begin{bmatrix} -1 & 1 \\ 0 & -3 \end{bmatrix} = [0\ \ -3]$$

So,
$$O_M = \begin{bmatrix} 0 & 1 \\ 0 & -3 \end{bmatrix}$$

$$\det(O_M) = 0$$

So, the system is not observable.

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Q. 47 Suppose that resistors R_1 and R_2 are connected in parallel to give an equivalent resistor R. If resistors R_1 and R_2 have tolerance of 1% each, the equivalent resistor R for resistors $R_1 = 300\,\Omega$ and $R_2 = 200\,\Omega$ will have tolerance of

(A) 0.5% (B) 1%

(C) 1.2% (D) 2%

Sol. 47 Correct option is (B).

Equivalent resistance when connected in parallel is

$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$$

Let $R_1 + R_2 = R_{sum}$

% Tolerance in $R_{eq} = \Delta R_1(\%) + \Delta R_2(\%) - \Delta R_{sum}(\%)$ ...(i)

$$\Delta R_{sum} = (300 \pm 1\%) + (200 \pm 1\%)$$

$$= \left[300 \pm \left(300 \times \frac{1}{100}\right)\right] + \left[200 \pm \left(200 \times \frac{1}{100}\right)\right]$$

$$= (300 \pm 3) + (200 \pm 2)$$

$$= 500 \pm 5$$

$$\Delta R_{sum}(\%) = \left(\frac{5}{500} \times 100\right)$$

$$= 1\%$$

Now, from eq (i)

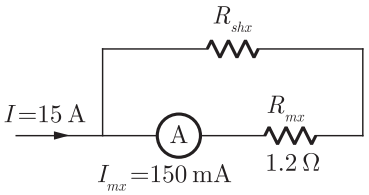
$$\Delta R_{eq}(\%) = 1\% + 1\% - 1\%$$

$$\Delta R_{eq}(\%) = 1\%$$

Q. 48 Two ammeters X and Y have resistances of $1.2\,\Omega$ and $1.5\,\Omega$ respectively and they give full-scale deflection with 150 mA and 250 mA respectively. The ranges have been extended by connecting shunts so as to give full scale deflection with 15 A. The ammeters along with shunts are connected in parallel and then placed in a circuit in which the total current flowing is 15 A. The current in amperes indicated in ammeter X is_____.

Sol. 48 Correct answer is 10.16 .

For ammeter X, Let shunt resistor be R_{mX}



$$I_{mX} R_{mX} = (I - I_{mX}) R_{snX}$$

$$0.15 \times 1.2 = (15 - 0.15) R_{snX}$$

$$R_{snX} = \frac{0.18}{14.85} = 0.0121\,\Omega$$

For ammeter Y, Let shunt resistor be R_{MY}

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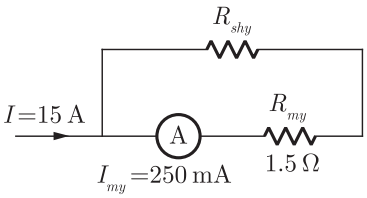


$$I_{MY}\,R_{MY} = (I - I_{MY})R_{snY}$$
$$0.25 \times 1.5 = (15 - 0.25)R_{snY}$$
$$R_{snY} = \frac{0.375}{14.75} = 0.0254\,\Omega$$

Equivalent resistance of ammeter X

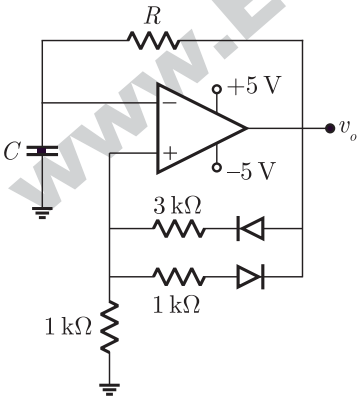
$$R_X = R_{mX} \,||\, R_{snX}$$
$$= 1.2 \,||\, 0.0121$$
$$\simeq 0.0121\,\Omega$$

Similarly $R_Y = 0.0254\,\Omega$

When connected in parallel, current in the circuit is 15 A, so current through ammeter X

$$I_X = \frac{R_Y}{R_X + R_Y} \times 15 \qquad \text{(Using current division)}$$
$$= \frac{0.0254}{0.0121 + 0.0254} \times 15$$
$$= 10.16\,\text{A}$$

Q. 49 An oscillator circuit using ideal op-amp and diodes is shown in the figure.



The time duration for +ve part of the cycle is Δt_1 and for −ve part is Δt_2. The value of $e^{\frac{\Delta t_1 - \Delta t_2}{RC}}$ will be _ _ _ _ _ _.

Sol. 49 Correct answer is 1.2.

Q. 50 The SOP (sum of products) form of a Boolean function is $\Sigma(0,1,3,7,11)$, where inputs are A, B, C, D (A is MSB, and D is LSB). The equivalent minimized expression of the function is

(A) $(\overline{B}+C)(\overline{A}+C)(\overline{A}+\overline{B})(\overline{C}+D)$

(B) $(\overline{B}+C)(\overline{A}+C)(\overline{A}+\overline{C})(\overline{C}+D)$

(C) $(\overline{B}+C)(\overline{A}+C)(\overline{A}+\overline{C})(\overline{C}+\overline{D})$

(D) $(\overline{B}+C)(A+\overline{B})(\overline{A}+\overline{B})(\overline{C}+D)$

Sol. 50 Correct option is (A).

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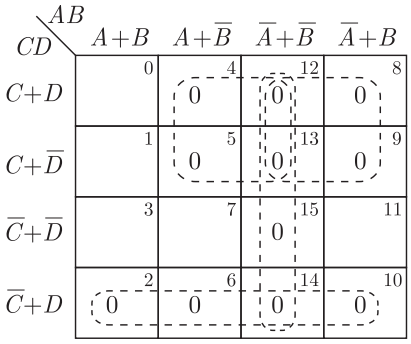
SOP Form, $F = \Sigma(0,1,3,7,11)$

POS Form, $F = \Pi(2,4,5,6,8,9,10,12,13,14,15)$

Now we represent the POS form on the k-map

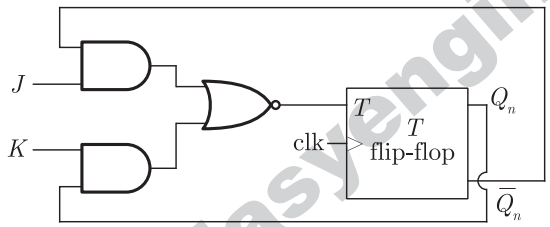


Here we enter 0's in those cells correspond to the max terms present in the given POS function.

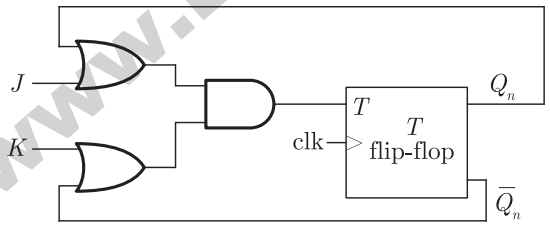
So, $F_{\min} = (\overline{B}+C)(\overline{A}+C)(\overline{A}+\overline{B})(\overline{C}+D)$

Q. 51 A JK flip flop can be implemented by T flip-flops. Identify the correct implementation.

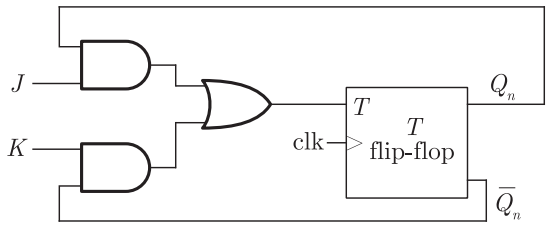
(A)



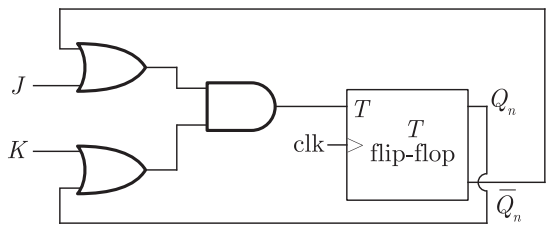
(B)



(C)



(D)



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Sol. 51 Correct option is (B)

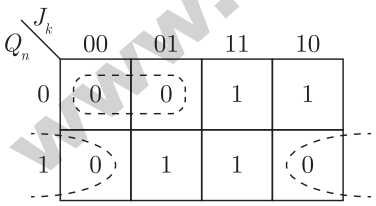
Here, T flip-flop is available and we want to convert it into J-K flip-flop. Hence J and K are the external input and T is the actual input to the existing flip-flop. So, we have to find expression of T in terms of J, K and Q_n.

Step 1: Construct the present-state-and-next-state table of a J-K flip-flop as shown in table below.

Step 2: We write the values of input T that is required to change the state of the flip-flop from Q_n to Q_{n+1}. The complete conversion table is as shown in table below.

External Inputs		Present State	Next State	Flip-flop Input
J	K	Q_n	Q_{n+1}	T
0	0	0	0	0
0	0	1	1	0
0	1	0	0	0
0	1	1	0	1
1	0	0	1	1
1	0	1	1	0
1	1	0	1	1
1	1	1	0	1

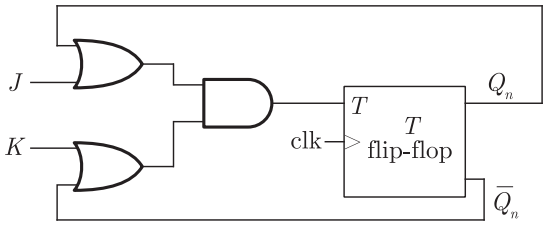
Step 3: Draw K-map for T



Writing expression of T in POS form

$$T = (J + \theta_n)(\overline{K} + \overline{\theta}_n)$$

Thus the logic diagram showing the conversion of T flip-flop to J-K flip-flop is show below.



Q. 52 In an 8085 microprocessor, the following program is executed

Address location	Instruction
2000H	XRA A
2001H	MVI B, 04H
2003H	MVI A, 03H

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2005H	RAR	
2006H	DCR B	
2007H	JNZ 2005	
200AH	HLT	

At the end of program, register A contains

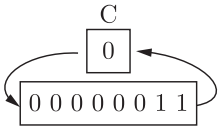
(A) 60H (B) 30H

(C) 06H (D) 03H

Sol. 52 Correct option is (A).

XRA A → A ← 00H Ex-OR (operation with accumulate)

2001H	MVI B, 04H	B ← 04H (04H started in B)
2003H	MVI A, 03H	A ← 03H (03H started in A)

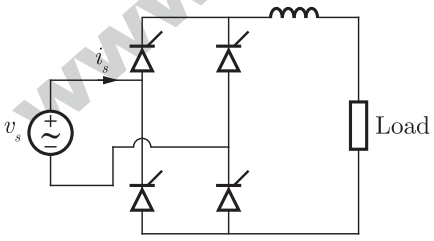


2005H	RAR	rotate accumulater right with carry
2006H	DCR B	B ← 03H (B decremented by one)
2007H	JNZ 2005	Jump to 2005H till B not comes equal to zero

So

B	C	A
03H	1	01H
02H	1	80H
01H	0	COH
00H	0	60H

Q. 53 A fully controlled converter bridge feeds a highly inductive load with ripple free load current. The input supply (v_s) to the bridge is a sinusoidal source. Triggering angle of the bridge converter is $\alpha = 30^\circ$. The input power factor of the bridge is



Sol. 53 Correct answer is 0.779 .

For a fully controlled bridge converter input power factor is given by

$$\text{Input P.F.} = \frac{2\sqrt{2}}{\pi}\cos\alpha$$

$$= \frac{2\sqrt{2}}{\pi}\cos 30^\circ$$

$$= \frac{2\sqrt{2}}{\pi} \times \frac{\sqrt{3}}{2}$$

$$\simeq 0.779$$

Q. 54 A single-phase SCR based ac regulator is feeding power to a load consisting of $5\,\Omega$ resistance and 16 mH inductance. The input supply is 230 V, 50 Hz ac. The maximum firing angle at which the voltage across the device becomes zero

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all throughout and the rms value of current through SCR, under this operating condition, are

(A) 30° and 46 A (B) 30° and 23 A

(C) 45° and 23 A (D) 45° and 32 A

Sol. 54 Correct option is (C).

The maximum firing angle at which the voltage across device becomes zero is the minimum firing angle to converter. It is given by

$$\phi = \tan^{-1}\left(\frac{\omega L}{R}\right)$$

$$\phi = \tan^{-1}\left(\frac{2\pi \times 50 \times 16 \times 10^{-3}}{5}\right) \simeq 45^\circ$$

Voltage across the device is zero is $v_o = v_i$

If input and output voltage are identical then $V_{o\,\text{rms}} = 230$ V

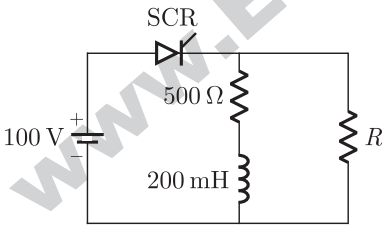
$$I_{o\,\text{rms}} = \frac{V_{o\,\text{rms}}}{|Z|} = \frac{230}{\sqrt{(5)^2 + (2\pi \times 50 \times 16 \times 10^{-3})^2}}$$

$$= \frac{230}{5\sqrt{2}}$$

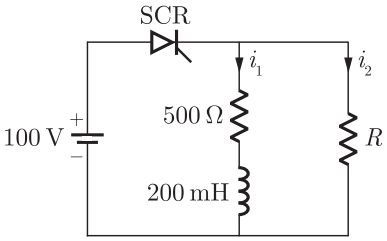
rms value of current through SCR

$$I'_{\text{rms}} = \frac{I_{o\,\text{rms}}}{\sqrt{2}} = \frac{230}{5\sqrt{2} \times \sqrt{2}} = 23 \text{ A}$$

Q. 55 The SCR in the circuit shown has a latching current of 40 mA. A gate pulse of 50 μs is applied to the SCR. The maximum value of R in Ω to ensure successful firing of the SCR is _____.



Sol. 55 Correct answer is 5882.35 .



Let us assume SCR is conducting $(I_L = 40 \text{ mA})$

$$i_i(t) = \frac{V_s}{R}\left[1 - e^{-\frac{R}{L}t}\right]$$

$$= 0.2\left[1 - e^{-\frac{500}{200 \times 10^{-3}} \times 50 \times 10^{-6}}\right]$$

$$i_i = 0.023 = 23 \text{ mA}$$

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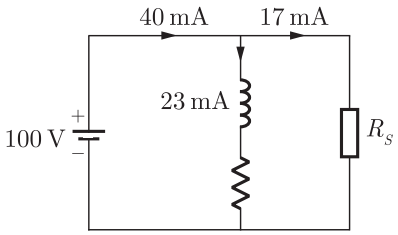

$$R_s = \frac{100}{17 \times 10^{-3}} = 5882.35\ \Omega$$

END OF THE QUESTION PAPER

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ANSWER KEY

General Aptitude									
1	2	3	4	5	6	7	8	9	10
(A)	(B)	(A)	(B)	(C)	(B)	(D)	(D)	(140)	(A)

Electrical Engineering									
1	2	3	4	5	6	7	8	9	10
(A)	(0.13-0.15)	(C)	(B)	(C)	(35)	(D)	(C)	(B)	(B)
11	12	13	14	15	16	17	18	19	20
(A)	(545-555)	(C)	(6.97-7.03)	(117-120)	(C)	(0)	(C)	(56-59)	(0.78-0.82)
21	22	23	24	25	26	27	28	29	30
(D)	(22-23)	(299-301)	(31.0-31.5)	(B)	(B)	(0.35-0.45)	(B)	(B)	(A)
31	32	33	34	35	36	37	38	39	40
(17.3-17.4)	(C)	(A)	(C)	(C)	(1.22-1.32)	(A)	(D)	(A)	(0.10-0.12)
41	42	43	44	45	46	47	48	49	50
(49.9-50.1)	(B)	(15300-15500)	(5)	(A)	(C)	(B)	(9.9-10.3)	(1.2-1.3)	(A)
51	52	53	54	55					
(B)	(A)	(0.74-0.82)	(C)	(6055-6065)					

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